Description of B-MC 20D

Local and remote control of Power Supplies

1. Local control via the front panel

Local control is done via a keyboard and an alphanumeric display. Commands can be initiated, corrected and executed or cleared. The text display gives an overview of status information of the addressed power supply. Chapter **1.** and sub-chapters describe the operation and functions of the local front panel with some remarks concerning the remote interface. A complete description of all remote interface functions will be given in chapter **2.** and following. Remote operation is an extra option of the system and not supported by all power supplies.

1.1 Theory of operation, arguments

The power supply control is housed in three 3 HU units in 19" format, one local control unit with front panel controls, and two extension units. The local unit is equipped with an interface according to IEEE 488.

The power supply controllers are activated with a push on the green 'Electronic Power' button. Here, the last extension should be switched on first, then the nearest extension, then the local control. This is necessary, since the local control tracks its extensions with a timeout-logic. The power supplies remain switched off, but all references, ADCs and DACs are now powered. We suggest not to switch 'Electronic Power' off during normal times of operation. As long as the main contactors remain switched off (see chapter **1.2.4**), there is no serious loss of energy, but you have the advantage of an always well tempered reference and regulation system. Also, it is now possible to switch on under remote control.

Commands are initiated by pushing one of the command keys, which then starts blinking. So the user can see which function is ready to accept an argument. Commands can be cancelled with an alternate command key. When a command needs an argument, it will be asked for on the alphanumeric display. The numeric value can be keyed in, errors can be corrected useing the key BACKSPACE. The value becomes effective upon a press of the SET key.

Most commands allow the use of the analog control knob. This systems is based on an optical encoder. Turning the knob slowly, the displayed value is changed bit per bit, turning fast will change with a more than proportional rate.

An additional possibility is offered by the arrow keys labeled ' ↑ ' and ' ↓ '. They change single bits and offer a repeat function.

The key SET completes the command and disables the analog knob and all numeric and arrow keys for this function.

1.2 Explanation of available functions

Every available command is listed below. In these sub-chapters, you will find the basic functions of the supply. In chapter **2.** the optional serial interface is described.

1.2.1 Change of local/remote state

A key switch is provided to change from manual to remote control and back again. A change of the remote state can be made at the local front panel only. This limitation is provided for security reasons. Remote operation means control via the interface IEEE 488. Even in remote mode of operation, all power supply ports are independently accessible for reading of status and values.

The appropriate read command is described below. Please note: For security reasons, there is no remote set command.

REM/	Check local/remote state - must be '1' for remote operation

1.2.2 Displayed values

The key DISP gives access to several different display modes. They are selected with a press of DISP, a numeric argument in the range from 0 to 3, and the SET key. The selected value shows up in the top right corner of the display, the next line gives a short form explanation of what is to be seen. The top left corner always gives the readout of the output current set value. The next table will explain all display modes.

Argument	Explanation	Description
any	[CUR]	Set value of current, as given to the DAC, resolution 16 bit, always displayed in leftmost position.
0	[ADC]	ADC readback of output current in Ampere, resolution 12 bit.
1	[VOLT]	ADC readback of output voltage in Volt, resolution 12 bit.
2	[DELAY]	Time remaining to the next command. The time is set with the key WAIT.
3	[RES]	Load impedance, given in Milli-Ohm (mOhm), calculated from ADC values with 12 bit resolution.

In display mode 0 to 3, the values are explained in the second line, separated by the port name and port number. The third line states the most recently effected command. So, the user has a possibility to check the command flow from the optional external interface.

The according remote commands are:

CUR/	Read nominal current of addressed port n in ampere
CHN/	Read output current of addressed port in ampere
VLT/	Read output voltage of port 0 in volt
RES/	Read load impedance of port 0 in milli-Ohm
TIM/	Read delay in seconds

Measured current and voltage of all power supply channels are converted with ADCs with a resolution of 12 bits. Each channel is equipped with its own ADC. Mean values are calculated of the most recent 256 values.. This is done in the background of the controlling program of the B-MC 20, values can be read without any timing overhead.

1.2.3 Reset of power supply

The power supply is equipped with a security system, the status is read out at the text display. Every error is displayed, multiple errors are flagged in a short form as given in the following table.

Error message	Short form	Affected ports	Action
Not Ready	R	1 .. 12 common	Switch off
Load Mismatch	L	1 .. 12 common	Switch off

Since each supply is equipped with its own local security system, only a summary interlock NOT READY is transferred to the controller B-MC 20. In case of an interlock, all affected supplies switch off without an intervention of the controller.

Error messages can be reset by pushing the RESET key. Now all status information should be in neutral condition. Operation of the RESET key is possible in local mode only.

To understand the remote command and its echoes, please refer to chapter **2.2**.

STA/	Read error message A
STB/	Read error message B
RST = 0	Reset error message

1.2.4 DC power on/off

This function is realized using the key named DC. The key is disabled in remote mode. The main contactor relay is activated with the argument '1', it is passivated with '0', the SET key completes the command.

After receipt of the command 'DC on', the nominal output currentof the addressed supply is set to zero, before the main contactor is activated.

Upon 'DC off', the power supply is ramped down to zero with the given current rates. Then the main contactor is switched off.

DCP/	Test DC-power
DCP = 0	DC-power off
DCP = 1	DC-power on

1.2.5 Change port

A port address can be selected by pushing the PORT key, selecting the correct port number, and pushing the SET key. The range of possible arguments is checked. Analog control knob and arrow keys may be used. This allows a fast overview of all status information of the system.

The second line of the display gives information which values are addressed, like

[CUR] 25V/5A/P09 [ADC].

This example stands for display of the nominal output current, name of the power supply / port no. 9, and ADC display.

Changeing the port number is possible in local as in remote mode, giving the user access to all information in the system. Also, the serial interface may access any port independend from the setting of the front panel.

PRT/	Read power supply port
PRT = nn	All following commands go to port nn

1.2.6 Current rate

The output current of the supply is always changed with a limited rate. This rate can be affected with the RATE key, the argument is given in amperes per second. If you switch off the green 'Electronic power' button, the rates of the system return to their initial values.

The power supply controller works with a fixed timing scheme, based on an internal clock of 1 millisecond. Upon any entry of a current rate, the power supply controller calculates a pair of rate and resolution informations. The rate gives the time interval between two increments or decrements, the resolution gives the size of increment / decrement. Typically, for fast rates, the system works with a rate of 1 millisecond and with a variable resolution, while for slow rates a resolution of 1 bit is used with a variable rate. In the range of the turn over point, the power supply controller calculates resolution/rate pairs which operate the DAC as smooth as possible.

RTC/	Read current rate in ampere per second
RTC = nn	Set current rate to nn

1.2.7 Set current

The current can be changed with the command key CUR. All numeric keys, arrow keys and the analog knob can be applicated, completion is done with SET. The resolution is limited to 16 bit by the DAC system of the power supply. A current can be set only to a selected port, which must be free from any errors. Please see chapter **1.2.4**.

The output current is always changed in a ramp. When the analog knob is turned very fast, the new setpoint might be changed at a very high rate. But still, the nominal output current follows at a rate not higher than specified.

CUR/	Read nominal current in ampere
CUR = nn	Set current to nn

1.2.8 Set delay

Whenever a hold or settling time may be neccessary, the key WAIT together with an argument giving the time in seconds can hold the command flow. The timer counts from this value down to zero. Arguments up to 65535 seconds are allowed. The display is switched to mode 5, this gives the readout of the timer, see chapter **1.2.2**.

Remote commands:

TIM/	Read delay in seconds
TIM = nn	Set delay to nn
TWT = 1	Start delay time

1.2.9 Control execution, command flow

Some commands, like activating a delay, can take quite a long time to be completed. The key STOP may be used to hold those commands. With START, the operation can be resumed, an additional press of STOP aborts the command in hold condition.

To understand this function, it must be known, that all commands take some time to be completed and before the next command can be activated. Even when the customer keys in the commands very fast, they are stored internally and completed one after the other. If now for any reason a command should take a very long time, it can be aborted. The command flow resumes with the next command.

An example:

The power supply is running at a current of 5 ampere, the ramp rate was set to 0.1 ampere per second. When you now switch off the power supply with 'DC', '0' and 'SET', it will take more a long time before the output current has been ramped to zero and the contactor reallly switches off. With 'STOP' and 'STOP' the command can be aborted to allow a new rate of e.g. 5 ampere per second. Now, the repeated DC off command will be completed within one second.

!EX = 0	Abort command
!EX = 1	Restart command
!EX = 2	Hold command

1.3 Enhanced modes of operation

The system is designed to work with four different modes of operation. After power up, it is set to mode 'MANUAL'. The function of the modes is described in chapters **1.3.2.1** to **1.3.2.4**. Some modes presume knowledge about the addressing of macro memories, so this function is described in chapter **1.3.1**.

1.3.1 Address of Macros

The control of the power supply can be operated automatically. Groups of commands can be stored in the battery buffered RAM. Ten memories, here called 'macros' can be used to hold logically grouped parts of a complete program. The macros are addressed with the key ADR, followed by 0 to 9 and SET. They remain addressed up to the next addressing or up to the completion of the AUTO mode.

MAC = nn	Set macro address to nn
MAC/	Read macro address

1.3.2.1 Mode 'MANUAL'

The mode is activated after power up or with the keys MACRO, ‘0’ and SET. In this mode, all components of the system may be controlled separately. Commands are effected immediately respective after completion of commands under progress. Most commands take some time to be executed, like ramping a current. During this time, additional commands are stored in a command buffer, which is organized in first in/first out order.

!MD = 0	Set mode ‘MANUAL’
MOD/	Read macro mode

1.3.2.2 Mode 'LEARN'

After selection of mode LEARN with MACRO, ‘1’ and SET, all additional commands are stored in the actually addressed macro buffer. Elder contents are cleared. Commands are not checked for plausibility and are not executed at this moment. Writing of a macro stops with activation of any different mode, like MANUAL. Commands are checked and executed with modes MACRO or AUTO.

An additional tip: If you use ADR, numeric keys and SET to include a macro address command inside a macro, you may include loops in your program. Those loops can be stopped with the STOP key only. Also, this allows to jump from one macro to the beginning of another, for example to build a common switch off or cycling macro.

!MD = 1	Set mode ‘LEARN’
MOD/	Read macro mode

1.3.2.3 Mode 'MACRO'

Activation of this mode starts execution of the actually addressed macro. This is done with MACRO, ‘2’ and SET. The mode may be interrupted, resumed and/or stopped with the keys START and STOP. Execution stops after execution of the last command.

!MD = 2	Set mode ‘MACRO’
MOD/	Read macro mode

1.3.2.4 Mode 'AUTO'

In this mode, all macros from 0 to 9 are executed one after the other. Commands are MACRO, ‘3’ and SET. Empty macros are skipped, after execution of macro 9 the system changes to mode MANUAL, this macro remains addressed. STOP and START keys can be useful.

!MD = 3	Set mode ‘AUTO’
MOD/	Read macro mode

2. Remote control

The power supply controller supports two remote interfaces, IEEE 488 and serial RS 232 C. The Local/Remote switch selects between local and remote operation, but does not specify IEEE 488 and / or RS 232 C.

2.1 Interface IEEE 488

The control unit is equiped with a standard IEEE 488 interface, designed to talk and listen. The use of this interface assumes familiarity with IEEE-488 standards, which are not included in this manual.

2.1.1 Set up of the system, addressing

On delivery, the controller is set to a base address of 5. Whenever a change of the IEEE address may be necessary, the key ‘IEEE’ (the text ‘Set IEEE address 0→30D‘ is displayed in the third display line, the LED is blinking) together with an argument sets a new parallel interface address, 'SET‘ for complement. Encoder and up/down keys are allowed.

Remote:	**IEA/**	Read IEEE address
	IEA = nn	Set IEEE address to... (0→30D)

On delivery, the unit uses 'CR/LF' with EOI as end sign. Also the end sign of the IEEE interface can be change. Two pushes on the 'IEEE‘ key enters the 'Set endsign‘ menu. The text 'Set endsign 0 > CR 1 > CR/LF‘ is displayed in the third display line, the LED on the key is blinking, the `SET‘ key leaves the menu, the LED stops blinking. Argument ´0´ sets the interface to endsign CR, ´1´ sets the interface to CR/LF. Up/down keys are allowed.

Remote:	**IEE/**	Read the IEEE endsign
	IEE = 0/1	Set the IEEE endsgin to CR or CR/LF

2.2 Interface RS 232 C

The control unit is equipped with a standard RS 232 C interface. The system is set to a data rate of 9600 baud, 8 data bits with MSB set to 0, 1 start bit, 1 stop bit, no parity. For special applications these values can be changed. The unit gives an echo of all received characters, thus allowing a readback check. A message has to be finished with CR (0D hexadecimal), the endsign is not echoed. For testing purposes it is possible to attach a serial operating terminal. The interface connector is wired as a DTE (data terminal equipment), what necessitates a connection with crossed data and handshake lines to most computers.

The interface serves the CTS line. This line has to be connected either to RTS on the computer side or to RTS of the interface, which will always be held at a positive level.

2.3 Commands and arguments

The following format of commands will be used with the interfaces. Command, argument and data are transmitted ASCII-coded, useing a fixed format. The short form 'nn' denotes an additional argument, e.g. for setting a current. The next table gives a list of all possible commands.

Commands and arguments can be separated from each other by nearly any count of spaces (20 hexadecimal), leading zeroes (30 hexadecimal) are allowed. Every entry is echoed back. All returned data is given back in a fixed format, error messages are given as a number, which can be easily decoded by a computer system.

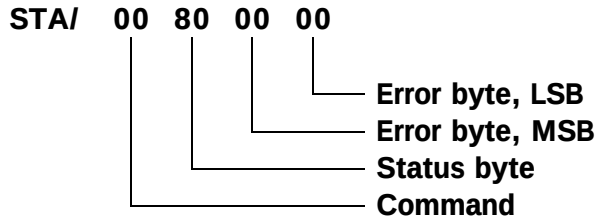
REM/	Check local/remote state - must be '1' for remote operation
PRT/	Read power supply port
PRT = nn	All following commands go to port nn
DCP/	Test DC-power
DCP = 0	DC-power off
DCP = 1	DC-power on
RTC/	Read current rate in ampere per second
RTC = nn	Set current rate to nn
CUR/	Read momentary nominal current in ampere
PNT/	Read final setpoint in ampere
CUR = nn	Set current to nn
STA/	Read error message A, see chapter **2.4**
STB/	Read error message B
RST = 0	Reset error message
CHN/	Read output current in ampere
VLT/	Read output voltage in volt
RES/	Read load impedance in milli-Ohm
TIM/	Read delay in seconds
TIM = nn	Set delay to nn
TWT = 1	Start delay time
!EX = 0	Abort command
!EX = 1	Restart command
!EX = 2	Hold command, restart or abort should follow
MAC = nn	Set macro address to nn
MAC/	Read macro address
!MD = 0	Set mode ‘MANUAL’
!MD = 1	Set mode ‘LEARN’
!MD = 2	Set mode ‘MACRO’
!MD = 3	Set mode ‘AUTO’
MOD/	Read macro mode
IEA/	Read IEEE address
IEA = nn	Set IEEE address to 0….30D
IEE/	Read IEEE endsign
IEE = 0	Set IEEE endsign to CR
IEE = 1	Set IEEE endsign to CR/LF

2.4 Status information

It can be useful to read the internal status message, useing the commands 'STA/' and 'STB/. Depending from what has happened at the commands before, this system gives either an error message or a status message. The error message refers to one of the commands preceeding the STA/ command. It can be interesting to insert STA/ commands in the command flow in a regular order.

Error messages	Explanation
E01	Command error
E02	Argument error
E03	Port error
E04	Local error
E05	Range error

Whenever an error message was found, the very next STA/ command gives the status information word of the power supply. When there is no error message pending, the STA/ and STB/ command give the status word. Every status bit is given a value, the values of multiple active status bits are added together. The tables at the next sides give a list of possible messages.

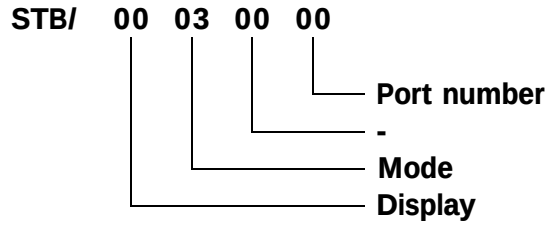


Error byte, LSB	Value, hex	Explanation	Affected ports
	1	Not Ready	1 .. 12
	4	Load Mismatch	1 .. 12
	40	Battery error	All in parallel

Error byte, MSB	Value, hex	Explanation	Affected ports
		No used	

Status byte	Value, hex	Explanation	Affected ports
	2	DC on indicator	1 .. 12 common
	80	Remote enabled	1 .. 12 common

Command	Value, hex	Command
	0	Idle
	3	Current set
	4	Current rate
	5	Time set
	A	Start delay
	B	Set mode
	E	Enable REM
	F	Enable LOC
	10	Set display
	11	PS port set
	12	Set power
	13	Reset power
	14	Polarity positive
	15	Polarity negative
	16	Set Macro address
	17	Reset Status
	19	Command flow set
	1A	Node ID set
	1B	Extern set
	1C	IEEE adr set
	1D	IEEE end set
	1E	Status reset



Port number	Value, hex	Explanation
	1 .. 18	Port 1 to port 12

Mode	Value, hex	Explanation
	0	Mode Manual
	1	Mode Learn
	2	Mode Macro
	3	Mode Auto

Display	Value, hex	Left display	Right display
	0	Current	ADC current
	1	Current	ADC voltage
	2	Current	Delay time
	3	Current	Load impedance

3. Hardware description

The system bus of the power supply controller allows prints to be located in any position. Due to the additional wiring of the controller, every board has its place to find its corresponding connectors. And also, even when there exist several boards of the same type, they need some additional configuration to be personalized for their purpose. An example: The controlling software expects the Power Supply Controller board PSC 9403 for supply no. 1 always at the same address.

The pinout of the controller bus connector is given here to complete the documentation and because even Bruker technicians don't know all lines by heart. The timing on this bus needs knowledge about asynchronous microprocessors from Intel 8080 up to Hitachi 64180.

It can give an idea to connect a multi trace oscilloscope to one of the lines **IOR/**, **IOW/** or **MEMW/** and to check the address lines **A0** to **A15** and the data lines **D0** to **D7** with this timing pattern. But with the typical asynchronous behaviour of the bus and with the somewhat complicated program structure, a technician will need more than just a lot of experience to know what happens. At least, it can be possible to find lines without connection or with short circuits.

Row a	Description	Row c	Description
1		1	
2		2	Gnd
3	Clock 1	3	
4	Clock 2	4	
5	MREQ/	5	A12
6		6	A0
7	RFSH/	7	A13
8	MEMR/	8	A1
9	RESIN/	9	A14
10	MEMW/	10	A2
11	M1/	11	A15
12	WAIT/	12	A3
13		13	+5V for backup (option)
14	D0	14	A4
15	BUSACK/	15	RESET
16	D1	16	A5
17	BUSREQ/	17	
18	D2	18	A6
19	INT/	19	
20	D3	20	A7
21		21	NMI/
22	D4	22	A8
23	INTA/	23	
24	D5	24	A9
25		25	
26	D6	26	A10
27		27	
28	D7	28	A11
29		29	
30	IOW/	30	IOR/
31		31	Gnd
32	+5V	32	

Connector of system bus

Serial connection to the extensions